Reviewing open challenges in Mental Tasks (MT-)based BCI user training

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Abstract

Traditional MI-BCI training programs could be further improved [1]. This can be done through guidelines [2]; user-centered design [3] and adaptive systems [4]. We conducted a literature review on several aspects of MI-BCI user-training, e.g. environment, cognitive support, exercises. Here, we highlight the elements that we identified as not sufficiently explored or formalized yet.

Concerning the training environment, these challenges include:

a) balancing between a relevant control task [5], a motivating environment, and the associated risk of imposing cognitive overload [6, 7, 8];
b) studying social aspects of training, e.g. feedback content [9].

Concerning instructions and cognitive support, it includes:

a) introducing the BCI to foster users' understanding and engagement;
b) evaluating the learnability/memorability of the MI-BCI skills and instructions [10];
c) assessing users' strategies [11];
d) selecting user-centered task(s) [12];
e) providing guidance based on user-only metrics instead of classification accuracy [13].

Current challenges for MI-BCI exercise design include:

a) implementing varied exercises instead of the only same one [1];
b) studying indirect/incidental MI-BCI training tasks, e.g. mindfulness meditation [14], physical preparation [15];
c) assessing online learners' states [16] and progress to provide adapted/adaptive environment (e.g. manipulating timing [17]);
d) exploring the suitable parameters of trials (e.g. order, duration, number [18]) and their influences on users' states and performances.

References

[1] R. Chavarriaga, M. Fried-Oken, S. Kleih, F. Lotte, and R. Scherer, "Heading for new shores! overcoming pitfalls in BCI design," *Brain-Computer Interfaces*, vol. 4, no. 1-2, pp. 60–73, 2016.

[2] F. Lotte, F. Larrue, and C. Mühl, "Flaws in current human training protocols for spontaneous brain-computer interfaces: lessons learned from instructional design," *Frontiers in Human Neuroscience*, vol. 7, p. 568, 2013.

[3] S. C. Kleih and A. Kübler, "Why user-centered design is relevant for brain–computer interfacing and how it can be implemented in study protocols," in *Brain–Computer Interfaces Handbook*, pp. 585–594, CRC Press, 2018.

[4] J. Mladenović, J. Mattout, and F. Lotte, "A generic framework for adaptive eeg-based bci training and operation," CRC Press, 2018.

[5] R. Vlek, J.-P. van Acken, E. Beursken, L. Roijendijk, and P. Haselager, "Bci and a user's judgment of agency," in *Brain-Computer-Interfaces in their ethical, social and cultural contexts*, pp. 193–202, Springer, 2014.

[6] J. Mladenović, J. Frey, M. Bonnet-Save, J. Mattout, and F. Lotte, "The impact of flow in an eeg-based brain computer interface," in *7th International BCI Conference*, (Graz, Austria), 2017.

[7] S. Enriquez-Geppert, R. J. Huster, and C. S. Herrmann, "Eeg-neurofeedback as a tool to modulate cognition and behavior: a review tutorial," *Frontiers in human neuroscience*, vol. 11, p. 51, 2017.

[8] Z. Emami and T. Chau, "The effects of visual distractors on cognitive load in a motor imagery brain-computer interface," *Behavioural brain research*, vol. 378, p. 112240, 2020.

[9] L. Pillette, C. Jeunet, B. Mansencal, R. N'kambou, B. N'Kaoua, and F. Lotte, "A physical learning companion for mental-imagery bci user training," *International Journal of Human-Computer Studies*, vol. 136, p. 102380, 2020.

[10] E. Loup-Escande, F. Lotte, G. Loup, and A. Lécuyer, "User-centered bci videogame design," *Handbook of digital games and entertainment technologies*, pp. 225–250, 2017.

[11] J. Bismuth, F. Vialatte, and J.-P. Lefaucheur, "Relieving peripheral neuropathic pain by increasing the power-ratio of low-β over high-β activities in the central cortical region with eeg-based neurofeedback: Study protocol for a controlled pilot trial (smrpain study)," *Neurophysiologie Clinique*, vol. 50, no. 1, pp. 5–20, 2020.

[12] A. Eliseyev and T. Aksenova, "Personalized adaptive instruction design (paid) for brain–computer interface using reinforcement learning and deep learning: simulated data study," *Brain-Computer Interfaces*, vol. 6, no. 1-2, pp. 36–48, 2019.

[13] F. Lotte and C. Jeunet, "Defining and quantifying users' mental imagery-based bci skills: a first step," *Journal of neural engineering*, vol. 15, no. 4, p. 046030, 2018.

[14] L.-F. Tan, Z. Dienes, A. Jansari, and S.-Y. Goh, "Effect of mindfulness meditation on brain–computer interface performance," *Consciousness and cognition*, vol. 23, pp. 12–21, 2014.

[15] S. C. Wriessnegger, C. Brunner, and G. R. Müller-Putz, "Frequency specific cortical dynamics during motor imagery are influenced by prior physical activity," *Frontiers in psychology*, vol. 9, p. 1976, 2018.

[16] E. A. Felton, J. C. Williams, G. C. Vanderheiden, and R. G. Radwin, "Mental workload during brain–computer interface training," *Ergonomics*, vol. 55, no. 5, pp. 526–537, 2012.

[17] L. George, L. Bonnet, and A. Lécuyer, "Freeze the bci until the user is ready: a pilot study of a bci inhibitor," in *5th International Brain-Computer Interface Workshop*, 2011.

[18] V. Rozand, F. Lebon, P. J. Stapley, C. Papaxanthis, and R. Lepers, "A prolonged motor imagery session alter imagined and actual movement durations: potential implications for neurorehabilitation," *Behavioural Brain Research*, vol. 297, pp. 67–75, 2016.